February 19, 2008
Revised August 26, 2009
Revised Jan. 30, 2013

VDOT
Traffic Signal Photo Enforcement
Engineering Analysis Template

Local Jurisdiction: _____ VDOT District:_____
(County/City/Town)

Intersection: _____
Street Name (Route #) at Street Name (Route #)

Intersection approaches under consideration for photo enforcement:

This Study performed under the direction of _____
(licensed professional engineer)

A. INTERSECTION & SIGNAL DATA (Include information on all approaches not just those under consideration for photo enforcement)

1. Signal Visibility

a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measure (ft)	Required (ft)*

*See attached table of minimum sight distance requirements from the MUTCD.

b. Are "SIGNAL AHEAD" signs present? ☐ Yes ☐ No
Are "SIGNAL AHEAD" signs needed? ☐ Yes ☐ No
Are other warning signs present in the vicinity of the intersection? ☐ Yes ☐ No
Explain: _____
_____

c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Yes or No)

2. Pavement and Markings Data

a. Stop bars in "good" condition? ☐ Yes ☐ No
Explain: _____
_____

b. Lane lines "clearly" visible? ☐ Yes ☐ No
Explain: _____
_____

c. Crosswalks "clearly" marked? ☐ Yes ☐ No
Explain: _____
_____

d. Pavement conditions (ruts, potholes, cracking, etc.)?
☐ Good Explain: _____
☐ Fair Explain: _____
☐ Poor Explain: _____

e. Pavement surface treatments exist? (rumble strips, texturing, pavers, etc.)
☐ Yes Explain: _____
_____
☐ No

3. Provide scaled diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.

B. SIGNAL TIMING & TRAFFIC DATA (Include information on all approaches not just those under consideration for photo enforcement)

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*

*Reference TE Memo 306.1 provided in Appendix F for calculation of Clearance Intervals

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and discuss whether signal timings (phasing, cycle length, progression, coordination, etc) are contributing to red-light running problem.

a. Do signal timings or phasing factor in as a possible contributor to RLR at this intersection?

☐ Yes Explain: _____

_____

☐ No Explain: _____

_____

b. List comments or recommendations on potential signal timing or phasing changes:

_____

_____

_____

3. Vehicle Detection Data

Approach and Movement	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)

4. 48-Hour Traffic Volume & Classification Data (Concurrent with 12- hour violation survey)

Approach and Movement	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles

C. CRASH & ENFORCEMENT DATA (Include information on all approaches not just those under consideration for photo enforcement)

1. Most Recent Three-Year Crash Data

Collision Type	3-year Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated With Red-Light-Running
Angle				
Rear End				
Head On				
Sideswipe				
Pedestrian				
Bicyclist				
TOTAL				

2. Crash Rate

a. Number of crashes per million entering vehicles: _____

b. Locality rate for comparison (if available): _____

3. Violation Rate

a. Number of red light running citations per year issued by law enforcement at the evaluated intersection, if available.
Number: _____ Year: _____

b.12-hour observed violation rate (conducted concurrently with traffic count survey)
Date: _____
Time Period: _____

Approach and Movement	Traffic Volume	Number of Violations

*per 1000 vehicles

4. Enforcement and Operational Issues

a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators.

_____
_____

b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation.

_____
_____

c. Are pedestrians at risk due to violations? ☐ Yes ☐ No
Explain: _____
_____

Number of pedestrians per hour? _____
Pedestrian crosswalk provided? ☐ Yes ☐ No

d. Have there been any changes to the operations of the intersection (signal timing, restriping, or increased enforcement) within the past three years? ☐ Yes ☐ No
Explain: _____
_____

Minimum Sight Distance

85th Percentile Speed (mph)	**Minimum Sight Distance (ft)**
20	175
25	215
30	270
35	325
40	390
45	460
50	540
55	625
60	715

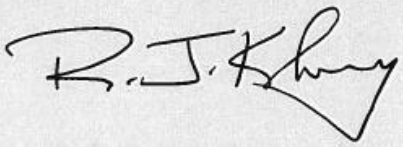
Table 4D-2 *Manual on Uniform Traffic Control Devices*, (2009 Edition) Transportation Research Board (TRB), Washington, DC, 2003

APPENDIX F

CLEARANCE INTERVAL TIMING
(TE MEMO 306.1)

VIRGINIA DEPARTMENT OF TRANSPORTATION

TRAFFIC ENGINEERING DIVISION
MEMORANDUM

GENERAL SUBJECT: Traffic Signal	**NUMBER:** TE-306.1
	TO SUPERSEDE: TE-306 inclusive of all addendum
SPECIFIC SUBJECT: Yellow Change Intervals and Red Clearance Intervals	**DATE:** January 7, 2013
	SUNSET DATE: N/A
DIRECTED TO: District Administrators Regional Operations Directors Regional Traffic Engineers Regional Operations Maintenance Managers Regional Traffic Operations Managers State Location and Design Engineer	**SIGNATURE: State Traffic Engineer** 

PURPOSE and NEED This memorandum will govern the method in which the timing of yellow change and red clearance intervals will be established for traffic signals operated by or for the Virginia Department of Transportation.

AUTHORITY Code of Virginia § 46.2-830

BACKGROUND The yellow change interval is the interval following a steady green, flashing yellow arrow or flashing red arrow interval during which a steady yellow signal is displayed. The purpose of the yellow change interval is to warn traffic of an impending change in the right-of-way assignment.

The red clearance interval is the interval that follows the steady yellow interval during which a steady red signal is displayed to potentially conflicting traffic movements at an intersection. The purpose of the red clearance interval is to provide additional time before conflicting traffic movements are released.

STANDARD The yellow change and red clearance intervals shall be applied for all signal timings in accordance with the procedures described in the following sections.

STANDARD (cont.)

YELLOW CHANGE INTERVAL (Equation 1)

$$Y = t + \frac{1.47 * V}{2a + 64.4g}$$

where:

Y =	yellow change interval, in seconds (s)
t =	perception-reaction time, in seconds (s)
V =	vehicle approach speed, in miles per hour (mph)
a =	deceleration rate, in feet per second squared (ft/s^2)
g =	approach grade, in percent divided by 100 to the nearest whole percent (negative for downgrade)

RED CLEARANCE INTERVAL (Equation 2)

$$R = \frac{w + L}{1.47 * V} - 1$$

where:

R =	red clearance interval, in seconds (s)
w =	intersection width, in feet (ft)
L =	length of vehicle, in feet (ft)
V =	vehicle approach or turning speed, in miles per hour (mph)

CALCULATION FOR THROUGH MOVEMENTS

Yellow Change Intervals shall be calculated using Equation 1 where:

t	is 1 s
V	is the 85th percentile vehicle approach speed as determined under free flow conditions, if known or as determined by a speed study*
a	is 10 ft/s^2
g	is measured approximately 400 feet upstream from the stop line, rounded to the nearest whole percent, and applied to all movements on the measured approach

Red Clearance Intervals shall be calculated using Equation 2 where:

w	is measured as defined in the Appendix
L	is 20 ft, unless a longer length design vehicle is appropriate based on a classification study and engineering judgment (see Engineering Judgment section)
V	is the same vehicle approach speed as used in the yellow change interval calculation for through movements

**If the 85th percentile value is not available, the posted speed limit plus 7 mph should be used as the vehicle approach speed value. For approaches with no posted speed limit, engineering judgment (see Engineering Judgment section) should be applied in determining the appropriate vehicle approach speed to be used in the calculation.*

STANDARD (cont.)

CALCULATION FOR TURNING MOVEMENTS

Left-Turn Applications

Yellow Change Intervals shall be calculated using Equation 1 where:

t	is 1 s
V	is the left-turn vehicle approach speed, which should be the posted speed limit** minus 5 mph, unless the 85th percentile left-turn vehicle approach speed is determined by a speed study
a	is 10 ft/s^2
g	is measured approximately 400 feet upstream from the stop line, rounded to the nearest whole percent, and applied to all movements on the measured approach

Red Clearance Intervals shall be calculated using Equation 2 where:

w	is measured as defined in the Appendix
L	is 20 ft, unless a longer length design vehicle is appropriate based on a classification study and engineering judgment (see Engineering Judgment section)
V	is the left-turn vehicle turning speed, which should be 20 mph, unless a higher left-turn vehicle turning speed is appropriate based on engineering judgment (see Engineering Judgment section)

***For approaches with no posted speed limit, engineering judgment (see Engineering Judgment section) should be applied in determining the appropriate left-turn vehicle approach speed to be used in the calculation.*

Right-Turn Applications

When right-turn termination occurs with an adjacent movement on the same approach, the yellow change and red clearance intervals shall be the same duration as calculated for that movement.

STANDARD (cont.)

SIGNAL PHASING CONSIDERATIONS

Yellow change and red clearance interval calculations shall be performed for through and turning movements as specified above. The calculated intervals shall be applied to signal phasing as follows:

- For a protected left-turn movement phase (leading and/or lagging), the yellow change and red clearance intervals shall be implemented as calculated. The intervals do not have to be the same duration for the adjacent through movement phase or opposing approach phases.

- For split phasing where a shared signal face is used to control a left-turn and through movement, the implemented yellow change and red clearance intervals shall be the longer of the calculated values for the left-turn and through movements to ensure motorists are presented with simultaneous termination. The intervals do not have to be the same duration for the opposing approach.

  When a shared signal face is not used, the protected left-turn movement phase guidance shall be applied.

- For a permissive or protected/permissive (leading and/or lagging) left-turn movement phase, the implemented yellow change and red clearance intervals shall be the longer of the calculated values for the left-turn and through movement phases. The intervals shall be the same duration for the left-turn and through movement phases on opposing approaches to ensure motorists are presented with simultaneous termination. This guidance also applies to flashing yellow arrow applications.

- For right-turn overlaps where termination occurs with an overlapping left-turn phase, the right-turn yellow change and red clearance intervals shall be the same duration as the overlapping left-turn phase intervals.

STANDARD (cont.)

MINIMUMS, MAXIMUMS, AND ROUNDING

The yellow change interval shall be no less than 3 seconds.

The red clearance interval shall be no less than 1 second.

There are no maximum yellow change and red clearance intervals. However, when the calculated interval for a specific movement at a given intersection is considered detrimental to intersection operations, engineering judgment (see Engineering Judgment section) should be applied to determine the appropriate value.

The calculated values for both yellow change and red clearance intervals shall be rounded to no less than the nearest one tenth (0.1) second.

ENGINEERING JUDGMENT

Engineering judgment may be exercised in situations that warrant the use of parameters or maximum interval values other than those specified herein. When engineering judgment is applied, the rationale to substantiate the engineering judgment decision shall be documented and maintained with the signed and sealed yellow change and red clearance interval timings required per TE-362.1 or any document that supersedes TE-362.1.

REFERENCE

Code of Virginia §46.2-833

2009 MUTCD, 2011 Virginia Supplement to the MUTCD (24VAC30-315-10)

TE-362.1 or any document that supersedes TE-362.1.

EFFECTIVE DATE

All yellow change and red clearance intervals signed and sealed after the issuance date of this memorandum shall be calculated and applied as specified herein.

CC:

Mr. Greg Whirley
Mr. Charles Kilpatrick, P.E.
Mr. Garrett Moore, P.E.
Mr. Jose Gomez, P.E.
Ms. Martha Kapitanov
Resident Administrators

APPENDIX: INTERSECTION WIDTH MEASUREMENT

This appendix provides guidance for determining the intersection width to be used in calculation of the red clearance interval for through and turning movements.

THROUGH MOVEMENT

The intersection width, *w*, should be measured from the back (upstream) edge of the approaching movement stop line to the far side of the intersection, as defined by the extension of the curb line or outside edge of the farthest travel lane, in feet. The intersection width should include standard right-turn lanes under signal control. Figure 1 illustrates the intersection width for through movements.

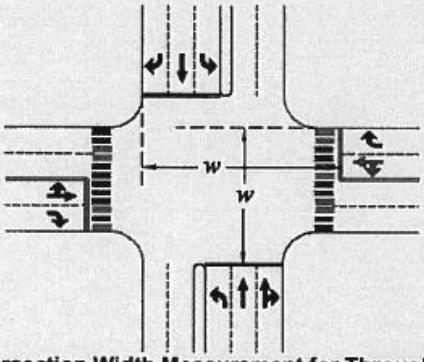


Figure 1 - Intersection Width Measurement for Through Movements

LEFT-TURN MOVEMENT

The intersection width, *w*, should be the approaching vehicle turning path measured from the back (upstream) edge of the approaching movement stop line to the farthest edge as defined by the extension of the curb line or outside edge of the farthest travel lane, in feet (see previous discussion). If multiple lanes are present (approach and/or receiving), the longest turning distance should be used in the calculation. Figure 2 illustrates the intersection width for left-turn movements.

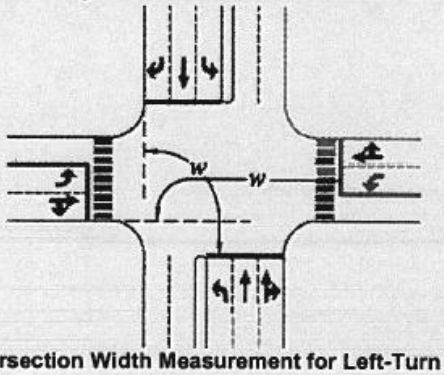


Figure 2 - Intersection Width Measurement for Left-Turn Movements

ENGINEERING JUDGMENT

If unusual geometrics are present (e.g., severe skews, channelized signalized turn lanes, crosswalks considerably offset from the intersection), then engineering judgment (see Engineering Judgment section) should be applied in determining the intersection width.